# A NEW ALLOPATRIC SEGREGATE FROM AND A NEW COMBINATION IN PINUS CEMBROIDES ZUCC. AT ITS SOUTHERN LIMITS

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## INTRODUCTION

Pinus cembroides Zucc. has, during the past decade, been the object of considerable attention. A geographical distribution map for P. cembroides Zucc. sensu lato was published earlier by Critchfield and Little (1966). Working northward from the southern region of the distribution in central Mexico, Robert has segregated Pinus johannis (Robert, 1978) and later Pinus catarinae and Pinus cembroides var. lagunae (Robert-Passini, 1981). P. catarinae Robert-Passini was based on a collection from a site studied earlier by Bailey (v. Bailey and Wendt, 1979) and is clearly identical with the earlier-published Pinus remota Bailey & Hawksworth (1979). It must therefore be considered a synonym (v. Bailey and Hawksworth, 1983). During the same period Bailey, with principal collaborators Hawksworth and Zavarin, has been working southward from the northern region of the distribution in southwestern U. S. A. and northern Mexico. As a result of these collaborative studies, the earlier segregates, Pinus cembroides var. remota Little (1966) and Pinus cembroides var. bicolor Little (1968), were elevated to specific status as P. remota (Little) Bailey & Hawksworth and P. discolor Bailey & Hawksworth (1979).

Recent studies disclose an additional segregate, proposed as subsp. orizabensis, at the extreme southern limits of P. cembroides s. lat., and indicate a need to elevate var. lagunae, found only in a limited area at the southern end of the peninsula of Lower California, to subspecific rank. Justifications additional to those published earlier for the reduction to synonymy of P. catarinae, and those now given for the establishment of the two taxa described below, including full details of chemical studies, further details of needle morphology, and interpretations, are in draft form and are planned for early publication by Zavarin, Snajberk and Bailey. The purpose of this report is to propose names and preferable ranks.

1. PINUS CEMBROIDES subsp. ORIZABENSIS D. K. Bailey subsp. nov.

Pinus cembroides auct. pro parte, non Zucc.
Pinus cembroides Gordon

Arbor ab 8 usque ad 10 m alta, similis Pino cembroidei, foliis tamen praecipue 3, nonnullis 4, rarissime 2 per fasciculum, 4 - 6 cm longis; fasciculi 1.3 usque 2.0 mm lati; paginae dorsales obscuro-virides, ventrales glaucae; stomata in utraque pagina; sulci longitudinales et irreg-

ulares in cortice arborum maturarum qui flavo-aurantiacum subcorticem patefaciunt; fasciculo-bracteae brevi tempore nigrae et tam conspicuae ut ramunculi scaberrimi fiant.

(Translation: A tree from 8 to 10 m tall, similar to Pinus cembroides, but leaves principally 3, sometimes 4, and very rarely 2 per fascicle, 4 - 6 cm long; fascicles 1.3 up to 2.0 mm thick; dorsal surfaces dark green, ventral surfaces glaucous; stomata on each surface; irregular longitudinal furrows in the bark of mature trees which expose the yellowish-orange inner bark; fascicle bracts soon black and sufficiently conspicuous as to make the small twigs rough.)

TYPE: MEXICO, Puebla, Mpio. Soltepec, lat. 19° 04' N, long. 97° 42' W, elev. 2370 m, along highway Mex 140, ca. 10 km southwest of San Salvador el Seco, 23 February 1983, D. K. Bailey 83-01 (HOLOTYPE: MEXU; ISOTYPES: ARIZ, CHAPA, COLO, E, ENCB, INIF, K, MO, NY, RM, TEX, UC, US, UTC).

## DISCOVERY AND DISTRIBUTION

The segregate named and described above was first recognized by the author as a specimen tree, No. P.372, in the Royal Botanic Gardens at Kew on 27 June 1977. Now labelled P. cembroides, it was acquired in 1910 from H. Clinton-Baker of Bayfordbury, Herts. as seed labelled P. nelsonii (D. R. Hunt, private communication). Today it is a substantial tree of approximately 9 m height and 25 cm diameter about 1 m above ground level. The original provenance is unknown. Study of two branchlets showed it to have fascicles mainly of 3 needles. Thus of 400 fascicles examined, 374 were of 3 needles, 24 of 4 and only 2 of 2. In this respect it differed markedly from the approximately 400 trees of P. cembroides s. str. already studied from all parts of the known distribution except that to the south and east of Mexico City in the states of Tlaxcala, Puebla and Veracruz. Then in March 1979 a stand of pinyon in the state of Puebla along highway Mex 140 some 10 km southwest of San Salvador el Seco was examined and a standard sample taken consisting of a branchlet from each of 10 trees together with such cone material as could be found. Wood cores were not taken at that time, but twig ends of the 10 samples were subsequently analysed for monoterpene constituents (Zavarin and Snajberk, private communication). These trees, upon detailed needle and chemical study, proved to be identical with the specimen tree at Kew and established the status of the latter as a distinct taxon rather than an aberrant specimen of P. cembroides s. str..

To establish the taxonomic significance of this finding it was necessary to make additional collections to learn as accurately as possible the distribution of pinyons resembling the Kew tree and those near San Salvador el Seco. Herbarium material was useful in suggesting possible collection localities, but could not be

studied in the detail considered necessary, nor could it provide information on tree-to-tree variation. It was also necessary to establish how near to these localities the distribution of P. cembroides s. str. extends. At that time the nearest 10-tree collection was from a site along highway Mex 120 some 7 km southwest of Pinal de Amoles in Querétaro. Thus the populations considered to be P. cembroides occurring between the Querétaro and Puebla collections required sampling to ascertain whether the two taxa meet on common sites with or without intermediate forms, or are geographically separated. Just prior to making the March 1979 collection it was learned from Dr. Jerzy Rzedowski that a collection, taken to be P. cembroides, had been made by M.-F. Robert at a locality on the mountains east of the city of Tehuacán, Puebla. This locality, represented by a herbarium specimen at the Escuela Nacional de Ciencias Biológicas (ENCB), is the southernmost and easternmost for any pinyon known at present. It is represented by collection 14 in Figure 1 which shows the geographical distribution of subsp. orizabensis as collections 8 through 14. Figure 1 also shows the southeastern part of the much more widespread distribution of subsp. cembroides (= P. cembroides s. str.) as collections 1 through 7. Collection 6 was made at the only known locality for subsp. cembroides in the state of Veracruz. This, the southernmost and easternmost locality known, is isolated from the nearest similar stands to the northwest by rather moist heavily vegetated country. To judge from the vegetation surrounding the pinyons at collection site 6, the climate must be locally rather dry and warm, in contrast with that at the collection sites for subsp. orizabensis. The latter sites are not only at higher elevations (some by as much as 400m) but are cooler and somewhat more humid as made evident by the presence of Tillandsia sp. on the pinyons.

Herbarium material exists for subsp. orizabensis from farther west than collection 12 in Tlaxcala, and Martínez (1948) lists a number of such localities, but a limited search for pinyons at some of these has failed, and it seem likely from the general condition of the land in Tlaxcala that pinyons at many of these localities no longer exist. Martínez also reports pinyons in the state of México at Dexcaní near Jilotepec. A recent search in this locality has been unsuccessful.

From the 14 collections shown in Figure 1 and described in detail in Table 1 it is concluded that a genuine gap exists between the southeasternmost representatives of subsp. cembroides and the northwesternmost stands of subsp. orizabensis, and no trees were found in the course of this study which exhibited significant evidence of intermediacy between the two taxa. However, in order to define the gap as precisely as possible, it is to be noted that collection 11 near Frijol Colorado was made near the southern end of a stand of subsp. orizabensis that extends north northeast by possibly as much as 20 km toward Jalacingo (v. Martínez, 1948). It is also likely that subsp. cembroides extends as much as 3 km east southeast of collection 6 near Teximalpa. It is therefore concluded

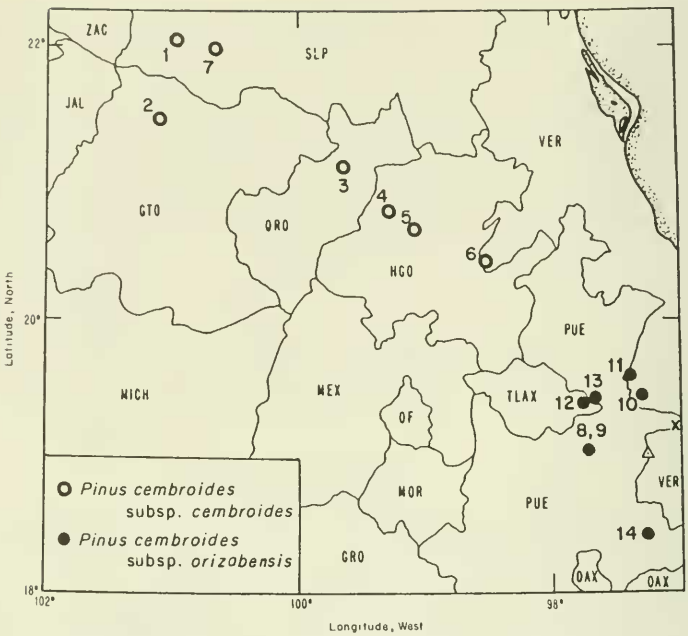


FIGURE 1. Geographic distribution of Pinus cembroides sensu lato at its southern limits. ▲ Mt. Orizaba, X village of Chichiquila.

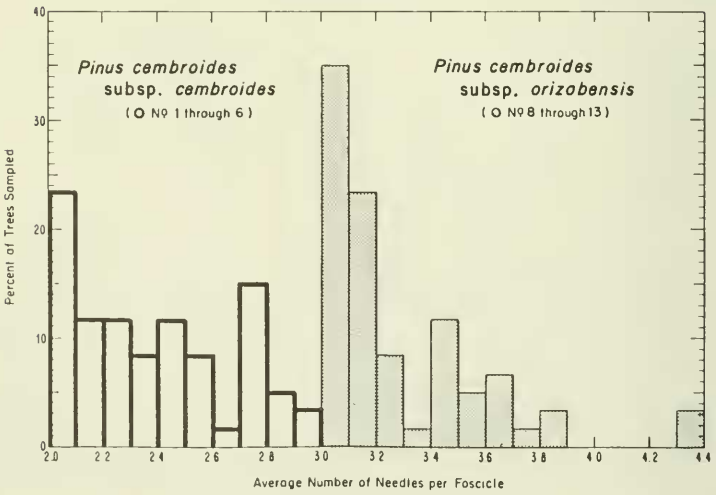


FIGURE 2. Needle-number distributions.

TABLE 1. Details of collections. Each collection consisted of a branchlet from each of 10 different trees. Twig ends and/or wood cores were also collected at each site, except numbers 2 and 7, from each tree for chemical analysis. Twig ends from the Kew tree were also taken.

| Collection No.(Fig.1) | Mpio. | State | Lat.(°N) | Long.(°W) | Elev.(m) | Collectors | Date |
|---|---|---|---|---|---|---|---|
| *Pinus cembroides* subsp. *cembroides* | | | | | | | |
| 1. Villa de Reyes (5 km WSW of Cerritos) | | SLP | 22° 02' | 100° 58' | 2320 | D. K. Bailey 79-04 & F. G. Hawksworth | 8 Mar. 1979 |
| 2. San Felipe (3 km ESE of Puerto Sandoval) | | Gto | 21 30 | 101 05 | 2100 | D. K. Bailey 81-17 & B. E. Berger | 5 May 1981 |
| 3. Pinal de Amoles (Along Mex 140, 7 km SW of Pinal de Amoles) | | Qro | 21 05 | 99 41 | 2400 | D. K. Bailey 78-34 & F. G. Hawksworth | 16 May 1978 |
| 4. Zimapán (3.7 km N of Pto. de la Estancia) | | Hgo | 20 47 | 99 18 | 1860 | E. J. Lott & Tom Wendt P-93 | 14 Dec. 1980 |
| 5. Cardonal (near Santuario) | | Hgo | 20 40 | 99 06 | 2380 | D. K. Bailey 80-12 & Tom Wendt 2499 | 10 Mar. 1980 |
| 6. Huayacocotla (1 km SE of Teximalpa) | | Ver | 20 25 | 98 31 | 2200 | D. K. Bailey 81-18, B. E. Berger & Juan Velasquez H. | 8 May 1981 |
| 7. Zaragoza (7 km NW of Mina las Cuevas) | | SLP | 21 59 | 100 38 | 2300 | D. K. Bailey s.n. & F. G. Hawksworth | 13 Nov. 1975 |
| *Pinus cembroides* subsp. *orizabensis* | | | | | | | |
| 8. Soltepec (10 km SW of San Salvador el Seco) | | Pue | 19° 04' | 97° 42' | 2370 | D. K. Bailey 79-01. F. G. Hawksworth & D. Wiens | 7 Mar. 1979 |
| 9. Soltepec (10 km SW of San Salvador el Seco) | | Pue | 19 04 | 97 42 | 2370 | D. K. Bailey 80-06 & Tom Wendt s.n. | 8 Mar. 1980 |
| 10. Perote (In malpais, 8 km S of Totalco) | | Ver | 19 27 | 97 17 | 2500 | D. K. Bailey 80-07 & Tom Wendt 2494 | 9 Mar. 1980 |
| 11. Perote (4 km WNW of Frijol Colorado) | | Ver | 19 35 | 97 22 | 2630 | D. K. Bailey 80-08 & Tom Wendt 2495 | 9 Mar. 1980 |
| 12. Atlzayanca (Santa Maria las Cuevas) | | Tlax | 19 24 | 97 44 | 2540 | E. J. Lott & Tom Wendt P-134 | 28 Jan. 1982 |
| 13. Libres (7 km SSE of Libres) | | Pue | 19 25 | 97 41 | 2410 | D. K. Bailey 80-11 & Tom Wendt 2498 | 10 Mar. 1980 |
| 14. Ajalpan (15 km E of Tehuacán) | | Pue | 18 27 | 97 14 | 2450 | D. K. Bailey 80-05 & Tom Wendt 2481 | 7 Mar. 1980 |

that the gap has a width of about 140 km.

For the record it should be noted that the heavy infestation of the dwarf mistletoe, Arceuthobium pendens Hawksworth & Wiens, on subsp. orizabensis at collection site 11 was sampled, and subsequently reported by Hawksworth and Wiens (1980) under the host name Pinus cembroides Zucc., the only name available at the time. In contrast at the type locality of the parasite, collection site 1, the infestation was very light, affecting only two trees (that could be found) of Pinus discolor. No dwarf mistletoe was found on pinyons at the other twelve sites comprising this study. In particular no dwarf mistletoe was found on subsp. cembroides at site 1.

## DISTINGUISHING CHARACTERS

To distinguish subsp. orizabensis from subsp. cembroides a rapid check on needle number or fascicle size is sufficient as is demonstrated by Figure 2 and the detailed numbers of Table 2. Collections 7 and 14 are omitted from the histogram of Figure 2. Material of collection 7 was destroyed inadvertently before complete analyses could be performed. Collection 14 differs from the remaining six collections of subsp. orizabensis in ways leaning very slightly toward subsp. cembroides. Until the general region of collection 14 can be studied further, its relative isolation from the other stands justifies its separate consideration as shown in Table 2, where the needle numbers for the Kew tree are also shown for comparison. It should be noted that collection 4 from

TABLE 2. Distribution of fascicle sizes (numbers).

| | Percent of Fascicles with Indicated Number of Needles | | | |
|---|---|---|---|---|
| | 2 | 3 | 4 | 5 |
| Pinus cembroides subsp. cembroides | | | | |
| 12000 fascicles, 60 trees Collections 1 through 6 | 62.52 | 37.46 | 0.02 | - |
| Pinus cembroides subsp. orizabensis | | | | |
| 12000 fascicles, 60 trees Collections 8 through 13 | 0.33 | 74.19 | 22.35 | 3.13 |
| Collection 14 2000 fascicles, 10 trees | 2.35 | 94.80 | 2.85 | - |
| Tree P.372, Royal Botanic Gardens, Kew 400 fascicles | 0.50 | 93.50 | 6.00 | - |

Zimapán, the generally accepted type locality for Pinus cembroides Zucc., is atypical as well. It comes from an exceptionally low and presumably dry location and yielded, in the standard sample of 2000 fascicles, 200 fascicles from each of 10 trees, an average fascicle size of 2.07. Of the remaining five localities, the average fascicle size varied from 2.30 to 2.65. Trees from greater elevation in the Zimapán region, including the type specimen Munich (examined while on loan to Kew) exhibit a substantially higher fraction of 3-needle fascicles. The inclusion of the Zimapán data has therefore somewhat distorted the histogram for subsp. cembroides as shown in Figure 2. The collections of subsp. orizabensis, studied in the same way, yielded average fascicle sizes ranging from 3.13 to 3.70. The slightly differing collection 14 yielded 3.00. Collection 13 had the very large average of 3.70 and most of the 5-needle fascicles shown in Table 2. The next largest average fascicle size was 3.32.

Other character differences of varying usefulness are;

Needle dimensions. Needles of subsp. orizabensis, including collection 14, are systematically somewhat longer and thicker than those of subsp. cembroides, though this is not obvious from casual observation. Nevertheless the needles of subsp. orizabensis are soft to the touch relative to the stiffer and sometimes more curved needles of subsp. cembroides.

Number and position of stomatal lines. From standardized samples of five fascicles per tree it was found that subsp. orizabensis has, on average, slightly fewer dorsal stomatal lines, and slightly more on the ventral surfaces than subsp. cembroides. However, histograms of the distributions show considerable overlap.

Number of resin ducts. For all practical purposes the needles of both taxa contain two resin ducts. Thus of more than 900 needles of subsp. cembroides considered in this study, all had 2 resin ducts. However among the 1200 needles of subsp. orizabensis, similarly considered, 10 needles were found with 3 resin ducts, and one needle was found with 4.

Foliage color. The ventral surfaces of the needles of subsp. orizabensis are usually much more glaucous than those of subsp. cembroides, and the dorsal surfaces are a darker more bluish green. In this respect the foliage of subsp. orizabensis more closely resembles that of Pinus discolor than that of subsp. cembroides. The latter has foliage which is usually somewhat yellowish green.

Needle retention and resinousness. Needle retention was found to be slightly greater for subsp. cembroides than for subsp. orizabensis. The average retention in years and its range are 4.2(3 - 6) and 3.6(2 - 5) respectively. Since early loss of needles is considered to be a means of moisture conservation, this could lead to the conclusion that evapo-transpiration is a more severe problem for the stands of subsp. orizabensis, except for collection 14, at an obviously rather wet locality, where the average needle retention was 5.0 years. Lest this result be interpreted solely as a climatic

response, it must be pointed out that the foliage of subsp. cembroides throughout its entire range is resinous and sticky to handle thus permitting better moisture retention, whereas that of subsp. orizabensis is comparatively non-resinous and clean to work with. Thus the difference in resinousness of needles of the two taxa is more useful as a character distinction than needle retention.

Bark of large mature trees. The bark of subsp. orizabensis resembles closely that of Pinus discolor and is in marked contrast with that of subsp. cembroides. Thus it exhibits little or no transverse fissuring with its irregular longitudinal fissuring. The bark is rather thin and shows yellowish-orange inner bark in the often broad fissures. Between fissures the bark tends to form in thin, rather ragged, concave layers. Subsp. cembroides, on the other hand, often exhibits irregular transverse fissuring as well as less conspicuous longitudinal fissuring, which results in the formation of coarse polygonal plates in the comparatively thick bark without the thin concave layers. The underbark, while yellowish, is less conspicuous in the fissures, and often does not show at all.

Small twigs after shedding needles and fascicle sheaths. The fascicle bracts of subsp. orizabensis are conspicuous and become nearly black in a few years. They tend to protrude thus giving the twigs a rough appearance and feel. In the case of subsp. cembroides the fascicle bracts are less conspicuous and somewhat smaller than those of subsp. orizabensis and result in comparatively smooth twigs after the passage of a few years.

Cones. Cones are very similar among all of the segregates of Pinus cembroides s. lat. with the exception of Pinus remota, and extremely variable even on the same tree, and from year to year. They are therefore of little use for distinguishing characters. Nevertheless it is possible to say a little. The cones of subsp. orizabensis are somewhat larger (i.e. longer) and harder than those of subsp. cembroides. The seeds of both have thick, hard shells relative to P. remota, and pink endosperms as revealed by Robert-Passini (1981) whose examples of subsp. cembroides included, unwittingly, some examples of subsp. orizabensis. Despite several similarities, pointed out above, between var. orizabensis and Pinus discolor, the endosperm of the latter, and of Pinus remota, is white.

Chemical differences. The difference between the two taxa in the percentage of 3-carene in wood from cores or twigs provides a limited character distinction. The percentage is small, usually 1 % or less, in subsp. cembroides, whereas it may be an order of magnitude greater in subsp. orizabensis. However, in the latter taxon it is highly variable within a stand, and some trees, or even most trees in some stands, exhibit only a little more than that found in subsp. cembroides, as for example collection 14 and the Kew tree.

## CHOICE OF NAME

The name orizabensis has been chosen for two reasons. Firstly it gives recognition to the position of Mt. Orizaba (Pico de Oriza-

ba) with respect to the collection localities reported above. Mt. Orizaba is indicated by a small triangle in Figure 1. Secondly it commemorates the first two reports of what is now, in the light of the geographical distribution, clearly identifiable as subsp. orizabensis on the slopes of the mountain. Though the pinyons await rediscovery on the mountain, the suffix, -ensis, indicating place of growth, origin, or habitat, seems appropriate.

The taxon was first recognized by Gordon who gave it the name Pinus cembroides Gordon in The Pinetum (1858). The name is a later homonym, having been used earlier by Zuccarini (1832). Gordon, for reasons that are not clear, regarded Pinus cembroides Zucc. as a synonym for Pinus llaveana Schiede ex Schlechtendal (1838) rather than the reverse. Thus Pinus cembroides Gordon represented to Gordon a different taxon. It may be supposed that Gordon's persistent emphasis on the distinctness rested mainly on needles in fascicles of 3 rather than of 2 and 3 on the same tree, and on cone size. It also rested on the "shorter, more glaucous . . . leaves" than those of P. llaveana, where "more glaucous" is the relevant character.

Gordon's name was based on material received from Hartweg (Gordon, 1846)

> ". . . who found it in the cold districts of the mountain of Orizaba, near the village of Chichiquila, attaining a height of 30 feet, at an elevation of 10,000 feet above the sea.
>
> Leaves in threes, from an inch to an inch and a half in length (on wild specimens), . . . Cones single and sessile, from $2\frac{1}{2}$ to 3 inches in length . .
>
> Judging from locality and appearance, this Pine is likely to prove hardy in England and is quite new to the collections of this country."

This last remark was prophetic indeed in view of the success of the Kew tree.

Further independent evidence that subsp. orizabensis, as P. cembroides Gordon, occurs or once occurred on the flanks of Mt. Orizaba is provided by Gordon (1858) who states, in reference of Pinus orizabae Gordon (= Pinus pseudostrobus Lindl.) that

> "It was first discovered by Hartweg on the eastern declivity of the Mountain of Orizaba, in Mexico, at the same elevation (10,000 feet) as P. cembroides, growing in company with that species and a bushy Juniper; . . . but not abundant."

Unfortunately the Hartweg material from "the cold districts of the mountain of Orizaba" has not come to light. Specimens of his earlier collection of 1839, No. 440, from the vicinity of Zimapán and Cardonal have been examined at Kew. This material, alluded to by Gordon in the heading of his 1846 paper, is quite certainly P. cembroides Zucc. as stated by Bentham (1840). It has fascicles of both 2 and 3 needles on the same specimen.

An unsuccessful attempt was made to make a collection for this study on the lower slopes of Mt. Orizaba, beginning at the village of Chichiquila, shown by the small "x" on Figure 1. Unfortunately the route found led to the northwest instead of southwest, and did not reach a sufficient elevation (Chichiquila itself is only at about 6000 feet or 1830 m) before leading to the main highway, Mex 140, to the west of collection 10. A route to higher elevations to the southwest of Chichiquila would quite possibly lead to the trees collected by Hartweg, if they still exist.

2. PINUS CEMBROIDES subsp. LAGUNAE (Robert-Passini) D. K. Bailey

comb. nov. Pinus cembroides var. lagunae Robert-Passini. Adansonia ser. 4, 3, sec. B, No. 1: 64, 1981

This pinyon occurs only in a small area of the Sierra de Laguna to the east of Todos Santos, between La Paz and Cabo San Lucas at the southern end of the peninsula of Lower California. Robert-Passini (1981) decided that it differed at varietal rank from P. cembroides s. str. in having thinner seed walls and more cotyledons. To justify raising the rank to subspecies the following additional characters distinguish subsp. lagunae (based on Bailey's collection 79-09 of 15 March 1979, 10 trees sampled each with cores) from subsp. cembroides (based on collections 1 through 6)

| | |
|---|---|
| longer needles, averages | 6.75 vs. 4.51 cm |
| thinner fascicles, averages | 1.19 vs. 1.32 mm |
| fewer stomatal lines per needle, averages | 5.91 vs. 7.58 |

also longer cone peduncles and perceptible prickles peduncles 2 to 3 mm thick, prickles ca. 0.5 mm long on cone-scale umbos.

But the most important and quantitative difference was the completely different monoterpene chemistry of subsp. lagunae compared with that of subsp. cembroides and subsp. orizabensis. Subsp. lagunae is high in sabinene and terpinolene as compared with subsp. cembroides and subsp. orizabensis, and has many chemical similarities to Pinus discolor. Both subsp. lagunae and Pinus discolor are low in α-pinene as compared with subsp. cembroides and subsp. orizabensis.

## ACKNOWLEDGEMENTS

The effort represented by this report has depended on no grants of any kind, but much is owed to many persons who have cooperated with the project in various ways involving the contribution of time. In particular thanks are due to the various persons listed, in addition to the author, in the column of collectors in Table 1, and to Frederick Ayer II for both hospitality and transportation in Mexico. The contributions in effort by Tom Wendt and Emily Lott must be singled out particularly, not only for their part in making the collections, but also for making possible the visit to Chichiquila. Thanks are also due to David Hunt of Kew first for supplying information about the "discovery" tree and for permission to collect the two

branchlets, and secondly for obtaining on loan from Munich the type specimen of Pinus cembroides Zucc., and making it available for study at Kew. Prof. J. N. Hough must be thanked for assistance with the Latin description of the new taxon. Dr. Rupert Barneby of the New York Botanical Garden gave extremely valuable advice and criticism of an earlier version of this account, much of which is reflected in the present version. Dr. Eugene Zavarin of the Forest Products Laboratory of the University of California gave permission to report in a preliminary and highly abridged form the results of the chemical analyses of the cores and twigs collected during the project. Most of all indebtedness must be acknowledged to Dr. Frank Hawksworth of the U. S. Forest Service for long-continuing assistance, encouragement and advice in carrying forward the pinyon project during the past decade.

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